Consultative Committee for Space Data Systems

DRAFT RECOMMENDATIONS FOR SPACE DATA SYSTEM STANDARDS

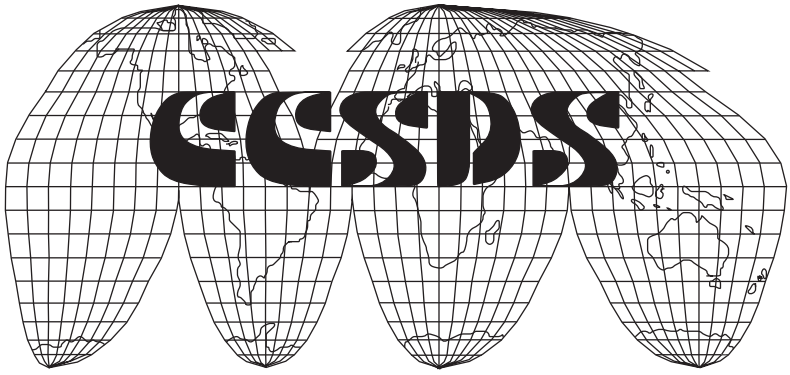
RADIO FREQUENCY AND MODULATION SYSTEMS—

PART 1
EARTH STATIONS AND SPACECRAFT

CCSDS 401.0-~~B~~P

~~BLUE BOOK~~PINK SHEETS

April 2002



2.4.3 SUBCARRIERS IN LOW BIT RATE RESIDUAL CARRIER TELEMETRY SYSTEMS

The CCSDS,

considering

(a) that at low bit rates, interaction between data sidebands and the residual RF carrier causes a performance degradation;

(b) that subcarrier modulation schemes eliminate interaction between data sidebands and the residual RF carrier but are bandwidth-inefficient;

~~(c) that some space agencies presently utilize ranging systems whose minor tones are below 20 kHz and whose major tone is 100 kHz, while others are planning to do so in the near future;~~

(c) that PSK modulation is a very efficient type of digital modulation because of its bit error performance;

~~(d) that simultaneous ranging and telemetry operation should be possible;~~

(d) that for Category A missions, it is more important to limit the occupied bandwidth while for Category B missions, it is more important to minimize the susceptibility to in-band interference.

recommends

~~(1) that CCSDS agencies use subcarriers with their residual carrier systems when transmitting low bit rates;~~

~~(2) that the subcarrier be placed between the 20 kHz and 100 kHz ranging tones, or above the 100 kHz tone.~~

(1) that CCSDS agencies limit the use of subcarriers to cases justified by technical reasons, i.e., low bit rate transmissions or radio science;

(2) that CCSDS agencies use PSK modulation for these subcarriers;

(3) that for Category A missions telemetry transmission, CCSDS agencies use sine wave subcarriers;

(4) that for Category B missions telemetry transmission, CCSDS agencies use square wave subcarriers.

2.4.8 MAXIMUM PERMISSIBLE SYMBOL ASYMMETRY FOR DIGITAL SIGNALS AT THE INPUT TO THE RF MODULATOR

The CCSDS,

considering

(a) that symbol asymmetry [1, 2] ~~(also referred to as mark-to-space ratio)~~ results in unwanted spectral components in the spacecraft's transmitted RF signal;

(b) that such unwanted spectral components can cause harmful interference to other users of the frequency band;

(c) that for a wide range of symbol [3] rates, current technology permits control of the symbol asymmetry such that these components can be reduced to a level of -60 dBc or lower;

(d) that, in addition to unwanted spectral components, symbol asymmetry results in data power and matched filter losses which should be minimized;

(e) that rise and fall time of digital circuits sets a limit on achievable symbol asymmetry;

recommends

that the symbol asymmetry [1, 2] shall not exceed 0.2 %.

NOTES:

1. **Definition of:** $Symbol\ Asymmetry = \frac{|\ long\ symbol - short\ symbol\ |}{long\ symbol + short\ symbol}$;

2. **Symbol asymmetry shall be measured at 50% of the peak-to-peak amplitude point.**

3. **A symbol is not unambiguously defined in the literature. For purposes of this Recommendation, a symbol shall be equivalent to:**

   - **a bit or an encoded bit or a chip in the case of NRZ waveforms;**
   - **half a bit or half an encoded bit or half an encoded chip in the case of Bi-ϕ waveforms;**
   - **half of the clock cycle for a squarewave subcarrier.**

2.6.7B TRANSPONDER TURNAROUND FREQUENCY RATIOS FOR THE 7145 - 7190 MHz AND 31.8 - 32.3 GHz BANDS, CATEGORY B

The CCSDS,

considering

(a) that many Category B space missions will use earth-to-space links in the 7145-7190 MHz band in conjunction with space-to-earth links in the 31.8-32.3 GHz band;

(b) that many of these space missions require coherency between the earth-to-space and space-to-earth links for the generation of navigation data;

(c) that for space missions which require coherency, a Transponder Turnaround Frequency Ratio (TTFR) that provides a maximum number of coherent channels must be defined;

(d) that three turnaround ratios are needed to allow almost full access of the entire 31.8-32.3 GHz band while maintaining coherency between the space-to-earth link and the earth-to-space link in the 7145-7190 MHz band;

(~~d~~e) that for reasons of standardization, of the on-board receiver design, a TTFR should be chosen in such a way as to conserve 749 as the numerator of the ratio for the 7 GHz uplink / 32 GHz downlink system [+];

(~~e~~f) that an odd number ~~is~~(749) has been selected as the uplink factor (numerator of the TTFR) and an even number ~~is~~should be selected as the downlink factor (denominator of the TTFR) to prevent downlink harmonic interference with uplink signals;

(~~f~~g) that, if the denominator of the TTFR can be factored into small prime numbers, e.g., ≤ 19, then conventional frequency multiplying devices, followed by band-pass filters, can be easily implemented;

(~~g~~h) that, if ~~the difference between the numerator and~~ the denominator of the TTFR can be factored into ~~prime numbers ≤ 19, then conventional frequency multiplying devices, followed by band-pass filters, can be implemented~~small prime numbers, it offers designers implementation flexibility;

~~(h) that the number of frequency multipliers should be reduced to minimize the delay in the spacecraft receiver's closed phase-locked loop path;~~

~~(i) that the denominator of the TTFR should be chosen to allow maximum Voltage Controlled Oscillator (VCO), Automatic Gain Control (AGC), and Diplexer implementation flexibility;~~

~~(j) that the denominator of the TTFR should be chosen to generate a minimum number of channels that fall into the *Inter-Satellite Service* allocation in the 32-33 GHz band;~~

(i) that a denominator of the TTFR of 3344 has been recommended by CCSDS and implemented on some transponders;

(j) that a denominator of the TTFR of 3360 has been implemented on at least one transponder and is being implemented on another;

(k) that a denominator of the TTFR of 3328 would complement the 3344 and 3360 denominators to allow almost full access of the 31.8-32.3 GHz band;

(l) that existing earth stations for Category B missions capable of receiving 31.8-32.3 GHz band can readily support multiple transponder turnaround ratios;

recommends

that CCSDS Agencies use ~~a~~the following Transponder Turnaround Frequency Ratios ~~of 749/3344~~ for Category B missions operating in the 7145-7190 MHz and the 31.8-32.3 GHz bands~~.~~:

749/3328; 749/3344; and 749/3360.

~~NOTE:~~

~~1. See CCSDS Recommendations 401 (2.6.2) B-1 and 401 (2.6.6B) B-1.~~